COMPUTER AIDED LEARNING APPROACH FOR THE STUDY OF THE PROPERTIES OF MATERIALS

Peter Arras

Abstract—This paper describes how an e_learning setup, supported with physical, remote and virtual laboratories can support engineering students in their material properties study. The structure of the course and division of the study materials are described. The educational environment used for virtual and remote laboratories is presented.

Keywords—e_learning environment, CALM, remote laboratory, virtual laboratory, material sciences

INTRODUCTION

Many engineering and science studies, including on material sciences, are based on theoretical knowledge. Engineering students nevertheless also need a lot of practical work/laboratories to acquire the knowledge and skills in procedures they will have to use in their professional career.

Material sciences is an important subject for all engineers, not only for material sciences engineers. Many – if not all – innovations in modern technologies are related to the use of new materials, or new technological methods of using existing materials. However, these achievements and new findings in materials sciences and technology seem to have not yet been meaningfully and successfully implemented into the educational content of primary, secondary and vocational schools, as well as universities. "*There should be greater interaction between materials scientists and engineers, production engineering and the design community to disseminate knowledge and information on the capabilities of materials." "There is a need to co-ordinate new courses for undergraduate and master's degrees that meet the needs of businesses in the UK for materials knowledge.*" [1]

Since time and other resources are limited to increase study time for material sciences, and for making available real life infrastructure in a classroom teaching environment, the introduction of a computer aided learning approach including labs (physical, remote, virtual labs) is considered as an efficient tradeoff between the necessity for lab work, and the above mentioned boundary conditions. Besides that, a computer aided learning approach in education can have significant didactic benefits.

In my approach the Computer Aided Learning Module (CALM) will not only help the student, but also the teacher [2]. The teacher can make use of the CALM in a very flexibly manner of this instructional support at any stage of his course to use the materials provided for teaching. Student will make use of it to (self) study the course, but also for preparation of lab-sessions, and for experimenting.

COMPUTER AIDED LEARNING MODULE (CALM) SETUP.

The setup of my approach in materials teaching is a blended learning approach. There is an hypertext supported learning environment, the Computer Aided Learning Module (CALM) which explains the theoretical basis of material sciences. This is done with course-book information, by showing examples of it and links to literature on the subject. It also contains all classroom materials (like slides, presentations, tables and figures) which are used in the face-to-face teaching sessions (see Figure 1).

As such, the CALM will act as the single-source-of-truth for students, containing their study materials in a single format.

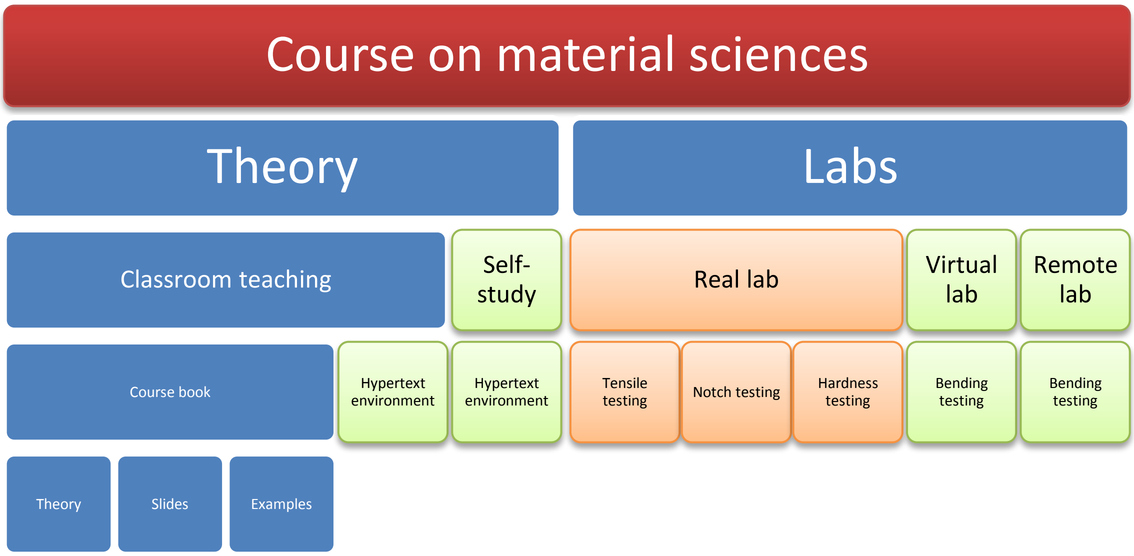

Figure 1 Structure of the Computer Aided Learning Module (CALM)

The material sciences theory itself is supported with lab sessions. Some physical (obligatory) lab sessions are provided in the study program on testing of materials. All necessary background information, manuals, safety procedures, are available in the CALM too. Furthermore virtual laboratories and remote labs are integrated, giving students the opportunity to experiment on phenomena in a extensive manner.

The CALM material is used during the classroom teaching sessions on material sciences and afterwards by students for self-study. It contains all materials, slides etcetera used in the lessons. As such the CALM enables students to study the course in one clearly defined manner: the look and feel of classroom teaching is the same as the look and feel of the self-study part. This will increase efficiency of the self learning.

The real labs are lab sessions on phenomena which use either heavy or very sensitive equipment, and cannot be automated.

The remote laboratory is an automated real laboratory (experiment) in which students can experiment themselves to find out about the laws of nature of other phenomena. The access to the laboratory is over the internet, with no need for manual interference.

The virtual laboratory is a simulation of a laboratory in which students can experiment with simulated experiments.

Research shows that to positively influence studying, student must be actively take part in using course materials and related stuff. The key aspects of active learning are the learners activity and engagement in the learning process. This is often put in contrast with traditional teaching (lecturing) where students passively receive information from the teacher. [3], [4]

The CALM incorporates active participation by the students by including the labs, by offering control questions (with feedback) at the end of chapters, and by providing a selection of media (pictures, movies, tables, graphs) to illustrate all of the course contents.

Assessment of the students is made dependent on the students role. If student/experimenter is a regular student, evaluation is done based on the reports they turn in on their assignments and by means of a formal exam. The hypertext supported method for them is a way of studying. If student/experimenter is an interested knowledge seeker, he she will be able to use to hypertext supported materials to broaden his knowledge, which he can evaluate by means of question lists in the CALM.

COURSE STRUCTURE

The course structure for the topic on material properties (material stiffness/shape stiffness) at present is a typical mixture of classroom teaching and lab-sessions. As such the CALM will use partly the same approach. (Table 1)

Students will take a classroom session in which the theoretical background of material stiffness will be explained. In the classroom teaching the CALM is used as the medium containing slides, tables, graphs and the course text on the topic.

Also use and purpose of the lab-sessions is explained and demo of the virtual/remote lab is given.

Next students have different lab-sessions: tensile test for determining material stiffness, Sharpy notch test for determining toughness of materials, hardness tests for determining material hardness. For the relation (and difference) between shape stiffness and material stiffness a bending is used. This physical lab test is substituted now with the virtual lab and the remote lab. As such students can work on it at any time, without having to use the real physical lab environment.

After taking the lab sessions students have to report on their experimental results. Assignments are described on the CALM. To enable direct feedback and for evaluation reasons, reports should be delivered in written form and not a web-form format. Web-forms are included in the CALM only to steer the learning process: in the theoretical section of the CALM, after each chapter a number of questions are inserted to check the progress through the material. Moving further is only possible after answering the questions. No reward or punishment is provided: if answer is wrong, an help/explanation window will open to explain the correct answer. We choose explicitly not punish incorrect answers as this will discourage the student. The CALM is not mended to be the evaluation tool, rather the tool to encourage studying.

Cycle for the topic on material properties is ended with another classroom session on theoretical aspects, and with feedback on the labs.

Present situation	CALM approach
- Printed course book on theory - Printed manual for laboratory sessions - Printed manuals for different testing machines (available only in laboratory) - Separate lessons on theory - Separate lab sessions spread in time to overcome scheduling problems -	- Course book on theory - All manuals in CALM. - Virtual laboratory - Remote laboratory (free to use at own chosen time) - Schedule of lessons integrated

Table 1 Comparison present situation and CALM approach

LAB ASSIGNMENTS

An important part of the CALM is dedicated to the different lab sessions students have to attend. In the present curricula lab sessions are included with a dual purpose: first to illustrate the theory and to deepen the knowledge by experimenting, secondly to teach students the skills they need for materials testing and treatment.

In the CALM 3 different types of lab sessions are included, physical labs, a virtual lab and a remote lab, to instruct the students on different parts of material sciences, and material properties (see Figure 2).

For the physical lab sessions, on tensile testing, hardness testing and notch testing, the contents on the CALM include theory about the tests, manuals of the testing machines, assignments, and preparations of the reports students have to make.

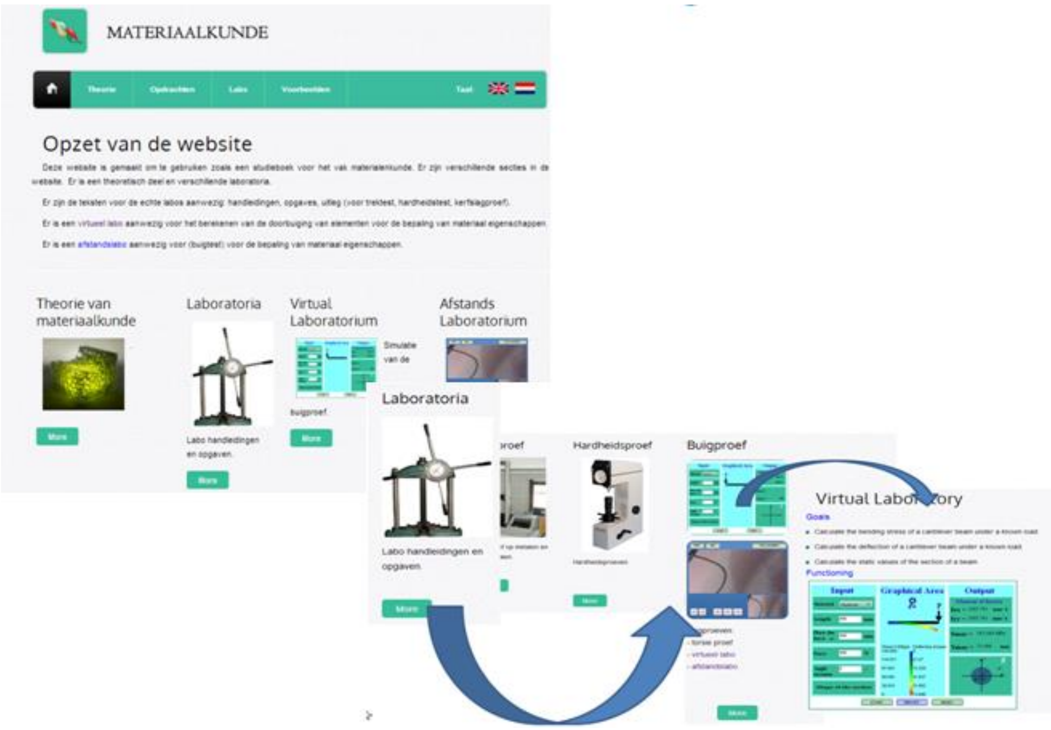

Figure 2 CALM hypertext environment.

The virtual lab and remote lab are included to substitute a traditional bending test in the lab. The virtual lab is a support simulated version of the test (see Figure 3) . In the virtual lab the students can calculate bending in a cantilever beam for a number of different materials and different beam sections. In the CALM is will be used to pre-calculate results for the remote lab.

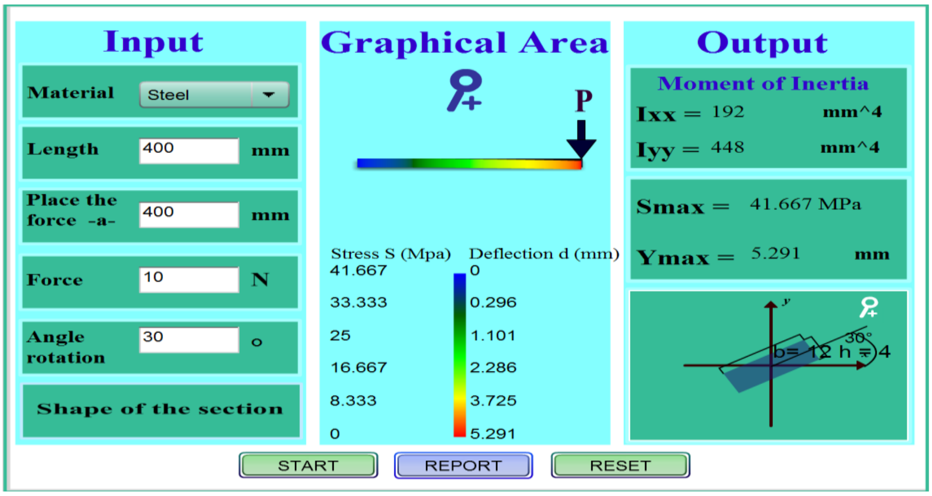

Figure 3 Virtual laboratory to calculate bending in cantilever beams.

The remote lab is used by students to experiment on material properties. Methodology of the lab is that a number of test specimens are bended by means of a known force (see Figure 4, Figure 5). With a know shape, students can then calculate the material property: Young's modulus. From a table with materials student must select the correct ones used in the different specimen. In combination with the virtual lab, students can check their solutions. Second motif for the use of the remote lab is the question of accuracy on the calculations. Students must do each test at least 4 times (as prescribed in the standards on material properties testing) and make a mean value of results for calculation. They also need to investigate in the influence of variations of the applied load (force), possible inaccuracy of reading measuring scales, and influence of dimensional tolerances on dimensions of the test specimen.

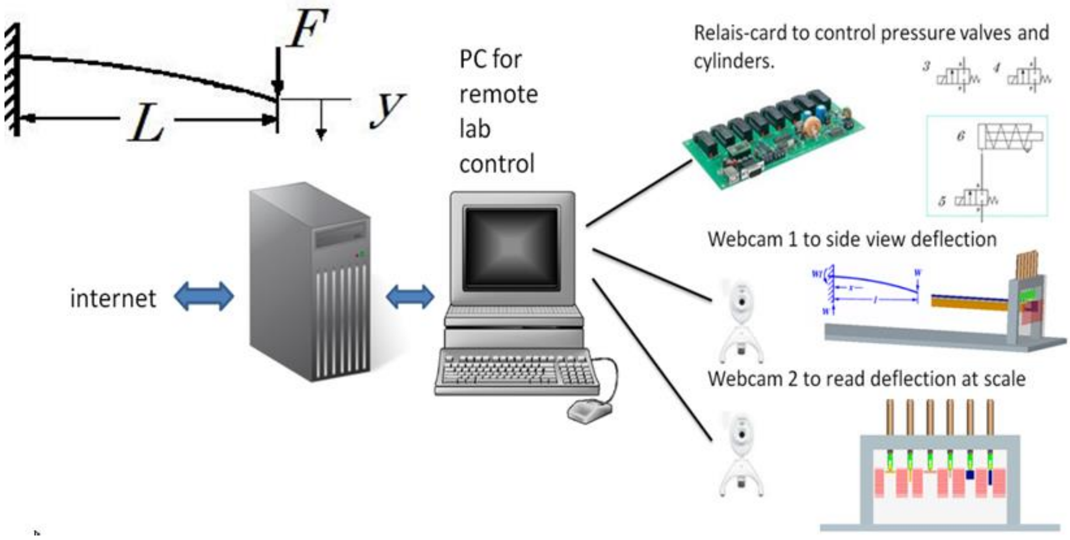

Figure 4. Remote lab for bending test setup

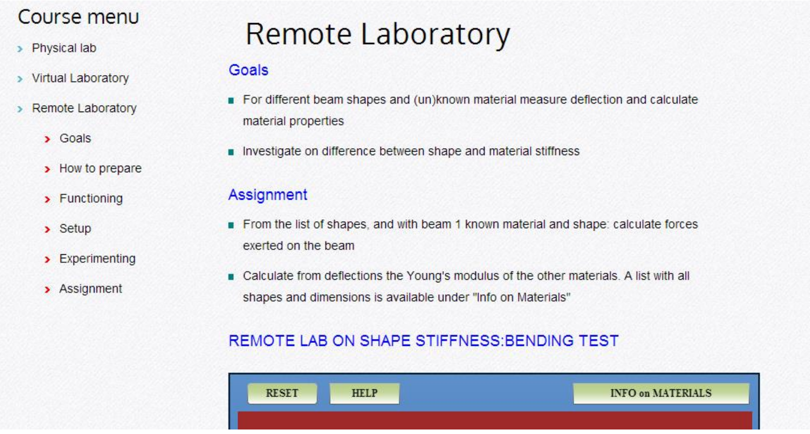

Figure 5 Entry page of remote lab (English version)

CONSTRUCTION

The CALM is hosted on a LINUX web-server offering html and php functionality, and is equipped with Red5 software for video-streaming and imaging purposes. A USB webcam is attached to the remote lab and a second camera is installed. This one is an IP-cam viewable over the internet. The layout of the web interface (as will be provided) and the lab hardware (as built) is shown in figure .

The virtual lab for the calculation of bending (displacement and stress) is constructed as a shockwave applet (see Figure 3).

The remote lab (see Figure 6) uses pneumatic components. Compressed air was chosen for safety reasons, and for ease of use. Control with electro-pneumatic valves is easy through the use of a USB-relay board connected to the computer. All operating at 24V DC makes it a robust and safe design. Test specimen are interchangeable and are substituted with another range once a week, to discourage copy and paste results in between groups of students. Two different forces can be applied to the test specimen, to study influences of force. [5]

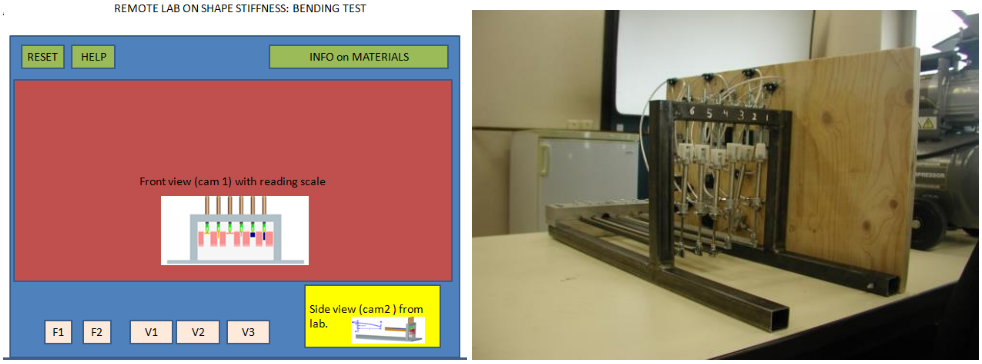

Figure 6 Remote lab: screen layout and hardware.

Adding a remote lab also implies a elevated level of security issues. [6] As the remote lab if free to use by students, a time limit per user is provided (locked on the IP-address of the visiting computer). Also checking for automated handling of the lab is installed to avoid hacking (and damaging) of the lab.

CONCLUSIONS

The completion of a Computer Aided Learning Module (CALM) for material sciences streamlines the course on material science for bachelor 1 students in engineering. It offers the opportunities to be used in classroom teaching and for self study. CALM is intended as a tool for studying material sciences, and is not meant to be a website, nor a wiki-page. It doesn't encourage clicking and jumping around, but tries to offer a kind of chronological structure in the materials which is considered as the normal learning path.

Integration of all course materials used in the current course and for the physical lab sessions in 1 learning environment (CALM) offers to students an easy to use single source of truth learning tool, where as in traditional approaches students often have to work with many different books and manuals.

The CALM is a flexible tool in studying the course on material sciences. It also helps students in the preparation of assignments and during lab sessions. The use of virtual and remote labs, independent of time schedules, helps students to time their study more to their own needs. Furthermore virtual and remote labs take of scheduling pressure from real physical labs.

The multimedia possibilities available in a computer aided environment make the course text more appealing and attractive to students and can explain a number of phenomena much easier as moving pictures are possible. This not only concerns the theoretical part, but also includes "living" manuals of equipment and how-to-videos for experiments and tests. These possibilities also cut on the effort and time that was put in during the lab sessions by teaching on explaining (and re-explaining) the simple handling on testing equipment.

BIBLIOGRAPHY

1 The materials innovation & growth team, "A strategy for materials," Department of trade and industry, Great Britain, 2006.

2 Z. Gadušová, A. Hašková, E. Malá and D. Munková, "Technology of Education Terminology in Use", Verbum o. s., Praha, Czech Republic, 2013.

3 Jochems, v. Merrienboer, Koper en Bastiaens, Een geïntegreerde benadering van e-learning, 2004.

4 Simons, v. d. Linden en Duffy, New learning, Kluwer Academic Publishers, 2000.

5 P. Arras, "Construction of a remote laboratory aimed at augmenting knowledge on properties of materials.," in *14th international conference on interactive collaborative learning*, Piestany, Slovak Republic, 2011.

6 T. Kozik en M. Simon, „Preparing and managing the remote experiment in education.," in *International Conference ICL IGIP 2012*, Villach, Austria, 2012.

CONTACT

Peter Arras
Department of Engineering Technology, Thomas More university college, Belgium,
Sint Katelijne Waver, J. P. De Nayerlaan 5,
E-mail: peter.arras@lessius.eu, URL www.thomasmore.be

LEKTOR

prof. Ing. Tomáš Kozík DrSc.
Katedra techniky a informačných technológií
PF UKF v Nitre